

A Review of Emerging Techniques of Marine Biotechnology and Its Future Prospects

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ABSTRACT

Marine organisms and microbes offer a wide range of high-valued and special compounds, which possess great potential to be developed further in many industries. A great number of natural compounds originating from marine organisms or microbes have been utilized in many industrial sectors, such as enzymatic production, the anti-ageing cosmetic industry, and antibiotic drug production. For instance, many compounds derived from marine life accustomed to striving in harsh and diverse environments have great potential to effectively boost production in these fields, for instance, the use of minimum energy-consuming enzymes and chemicals of higher molecular mass in cosmetics and skin care industries. Enzymes thriving in harsh environments in the deep sea are applied not only in heat-sensitive processes such as gelling and clarifying but also in food industries. In the anti-ageing cosmetic industry, marine organisms and microbes that are sources of polysaccharides (EPS and HE 800) and PUFAs (DNA, EPA, and Omega-3 fatty acids) are widely used in production. The antibiotic industry is forecasted to achieve phenomenal growth from the use of various chemicals classified as *Pseudomonas* sp. UJ-6, FStm2, or SWtm11. Moreover, many scientists and analysts foresee more growth in those industries by taking advantage of marine-derived compounds and keeping pace with further research and discoveries. Hence, the aim of this paper is to evaluate the present techniques of marine biotechnology in the three significant fields of industry above-mentioned. It also intends to analyze the future prospects of marine biotechnology as an emerging field of interest.

Keywords: Biotechnology; Marine biotechnology; Enzymes; Antiaging cosmetics; Antibiotics; Marine-derived compounds

Subject: Biology

INTRODUCTION

In the last few decades, considerable attention has been given to marine biotechnology in many industrial fields as an emerging technology that possesses an unknown potential to be developed. Bacteria (anaerobic heterotrophic bacteria) were the first organisms to appear on Earth [1]. Their first appearances have been made in the first oceans, not on the surface. In fact, according to a study published by PLoS Biology (2013), around 86% of the species on land and 91% of those in the seas have yet to be discovered, while 71% of the planet is covered by the ocean [2]. However, despite the enormous developmental potential of marine biotechnology, vast quantities of resources, including time, are sacrificed in the "land" biotechnological research sector.

However, in spite of the scarce resources exhausted for marine biotechnology research, extensive quantities of new discoveries and development have been made until now. Research has been done in various sectors of research: enzymes, proteins and gelatins, polysaccharides, nutraceutical industries, cosmetics, and antibiotics [3]. In particular, marine-derived compounds have unexpected potentials that differentiate them from land compounds. This paper aims to review current discoveries in marine biotechnology sectors and their potential as a newly developed area of research [4].

Aims and Objectives

An attempt has been made to review the emerging techniques of marine biotechnology in three different fields of industry (enzymes, anti-ageing cosmetics, and anti-biotics) and emphasize their future prospects with specific examples.

MATERIALS AND METHODS

- Previously researched papers/reports/review papers include cases of new developments in marine biotechnology and expected future prospects.
- Statistics/ numeric data from online reports (www.grandviewresearch.com)

RESULTS AND DISCUSSION

I. Emerging techniques in marine biotechnology

A rise in the world's average age has resulted in high demand for nutritional supplements such as omega 3, proteins, etc. These aspects have led to the development of research in marine-derived compounds. As reported by Rosalee S. Rasmussen and Michael T. Morrissey, enzymes extracted from fish and marine microorganisms, in new biotechnological and industrial areas have been emerging because of their special ability to function at extreme pH and temperature [5]. Those characteristics of marine-derived technology were created in the harsh environment of the deep sea. In addition to this, the advantages that they provide in various environmental conditions can be used for industrial areas. These two features are extensively appealing to industrial sectors that prefer minimum energy-consuming enzymes and effective production.

In a detailed view, in the last few decades, proteins, collagens, and gelatins derived from marine organisms have been pursued by many businesses. This is because of the excessively lower temperature of enzymes and compounds. These were used in heat-sensitive processes such as gelling and clarifying [5].

Moreover, in accordance with the same research, polysaccharides derived from marine organisms such as algae, carrageenan, algins, and agar are used in many food industries because of their ability to form gels and act as thickeners or stabilizers [5].

A view from the cosmetic industry can also be added here. Resende et al. studied the trends in the use of marine ingredients in anti-ageing cosmetics [6]. Their analysis of the trend revealed that the number of consumers of marine-derived anti-ageing cosmetics is increasing. Undoubtedly, algae are the most commonly used marine-derived ingredient, in particular, the anti-ageing section, because of their biodiversity, easy cultivation environment, and growth modulation. The review focusing on cosmetic potential from marine natural resources came to the conclusion that microbial biotechnology should be crucial in finding a sustainable way to harvest bioactive compounds and metabolites to gain good quality compounds as perfect cosmetic ingredients.

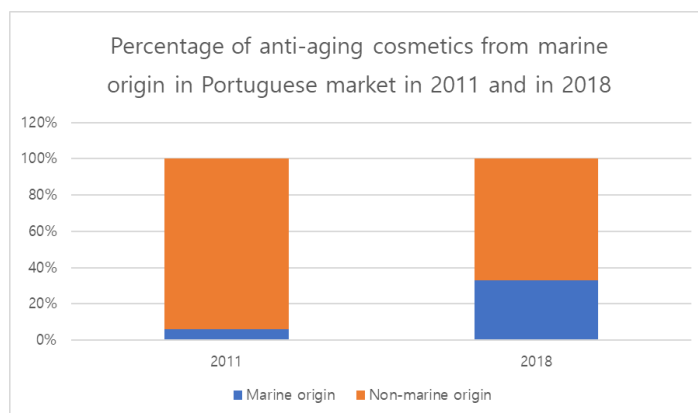


Figure 1 [6] The percentage of anti-ageing cosmetics of marine origin in the Portuguese market in 2011 and in 2018

Resende, D. I.S.P., Ferreira, M., Magalhães, C., & Lobo, J.M. S. (2021). Trends in the use of marine ingredients in anti-ageing cosmetics.

As can be seen in Figure 1, the commercialized Portuguese market was analyzed to compare the composition of cosmetic products derived from marine origins. In 2011, only 6% of anti-ageing cosmetics were of marine origin. However, remarkable growth was seen in 2018, as approximately 33% of anti-ageing cosmetics were marine-derived [6].

Further, antibiotics derived from marine organisms have been proving their ability in recent years. Auckloo and Wu (2016) studied antibiotics derived from marine organisms [7]. Their findings revealed that the marine biosphere offers unique and special biological properties that can be diversely used for the development of many antibiotics, namely antitumor, anticancer, antimicrobial, antithrombotic, and anti-inflammation etc. Many scientists consider an enormous number of marine organisms or microbes - including sponges, cnidarians, molluscs, marine bacteria, and fungi - that reside in marine sediments to be highly valued. Those organisms and microbes that thrive under specific conditions, not only extreme temperature and pressure but also salinity, dissolved oxygen, and nutrients, bring light to scientists while allowing wider research in antimicrobials or antibiotics having great potential as treatments for diseases.

Antibiotics produced by different marine organisms contain various chemical classes, namely: protein, lipopeptides, thiopeptides, dicarboxylic acids, polypeptides, macrolactones etc [7].

Table No. 1 [8] The world-common antibiotic-producing marine bacteria and the countries that produced them

Sr#	Isolated strain	Identified as	Country	References
1	<i>Pseudomonas</i> sp. UJ-6	—	Korea	[35]
2	FSIm2	<i>Pseudomonas putida</i>	Malaysia	[25]
3	SWtm11	Not identified	—	—
4	SCIm12	<i>Vibrio proteolyticus</i>	—	—
5	PRps9	<i>Vibrio proteolyticus</i>	—	—
6	MN38	<i>Actinomycetes</i>	Iran	[36]
7	MN39	—	—	—
8	MN3	—	—	—
9	KSP-SS-06-1C/1	<i>Actinomycetes</i>	India	[37]
10	BC-1	—	India	[38]
11	MAI2	<i>Pseudomonas aeruginosa</i>	Ghana	[9]
12	PG-01	<i>Pseudoalteromonas piscicida</i>	Iran	[39]
13	C11	Not identified	India	[40]
14	C12	Not identified	—	—
15	MS-3/48	<i>Pseudoalteromonas</i> sp.	Mexico	[41]
16	MMG-28	<i>Pseudomonas</i> sp.	India	[42]
17	VITSVK5(FJ9 73467)	<i>Nocardioopsis</i> sp.	India	[43]
18	<i>Actinomycetes</i>	Not identified	USA	[44]
19	NPS008920	genus <i>Marinispora</i>	USA	[45]
20	<i>Cyanobacterium</i>	<i>Cyanobacterium fischerella</i>	Israel	[46]
21	<i>Bacillus</i>	<i>Bacillus subtilis</i>	Pakistan	[47]
22	<i>Bacillus</i>	<i>Bacillus lecheniformis</i>	—	—
23	<i>Pseudomonas</i>	<i>Pseudomonas aeruginosa</i>	—	—
24	<i>Pseudomonas</i>	<i>Pseudomonas putida</i>	—	—
25	<i>Brevibacterium</i>	<i>Brevibacterium frigoritolerans</i>	—	—
26	PNG276	<i>Brevibacillus laterosporus</i>	PAP New Guinea	[48]
27	Nov.O-BC30t	<i>Pseudoalteromonas phenolica</i>	Japan	[49]
28	—	<i>Vibrio vulnificus</i>	USA	[50]
29	—	<i>Vibrio(Beneckea) Harveyi</i>	Texas	[51]
30	strain 18 (=NCMB 1890)	<i>Alteromonas rubra</i>	France	[52]
31	—	<i>Vibrio marinus</i>	—	[53]
32	—	<i>Pseudomonas bromoutilis</i>	New York	[54]

Saleem, S., & Iqbal, A. (2015). Marine Environment: A Potential Pool of Isolating Antibiotic Producing Bacteria with Novel Characteristics.

The table published by Saleem and Iqbal (2015) shows the world-common antibiotic-producing marine bacteria and the country that produced them. Although some isolated strains are unidentified yet, it is shown that marine-derived compounds have highly valuable potential to be developed [8].

Moreover, it is of major interest for scientists to develop the mode of action of antibiotics against pathogens that will kill or disrupt their target without any side effects. For example, the top priority to be managed by scientists is the growth of resistance of bacteria to antibiotics as it increases the death rate of infectious diseases. As a result, it can be seen that research and discovery of more chemical classes in marine-derived compounds as well as developing newly - developed technologies should be supported further.

II. Future Prospects

As discussed, marine microbial enzymes are of special interest to many researchers and experts in the enzyme industry. Marine biotechnology research is now being boosted by many researchers and new discoveries - including techniques like screening, characterization, recombinant production, optimization, and structure analysis of enzymes - are being developed [9].

The use of enzymes has increased past last few decades and, in many countries, marine biotechnological enzymes have been considered a perfect emerging technique with excellent prospective. For instance, Japan is one of the countries that constantly increases its support for marine microbial enzyme research, and since 1992, the government has made a future plan to develop and discover clone proteins and enzymes derived from marine organisms or microbials. Moreover, Canada, Finland, Russia, and Spain have taken the first step towards marine bio-enzyme research [9].

Besides, research on anti-ageing cosmetics containing marine-derived substances has received critical attention from the cosmetic market. Higher molecular weights have been highlighted in the industrial field for their effective softening and smoothing effects on the skin. Therefore, several marine-derived various molecules, including fatty acids (sophorolipids, rhamnolipids, mannosylerythritol, and PUFA), polysaccharides, and proteins (especially collagen), are widely used in the production of skin-care cosmetics [10].

Table No. 2 [9] Types of marine-derived compounds used in the production of anti-ageing cosmetics

Main Categories	Bioactive compounds	Action	Source Microorganisms
Polysaccharides	EPS	Emulsifying, thickening, absorption and gel formation and anti-wrinkles □	Different marine environments, including extreme ecosystems. <i>Pseudoalteromonas</i> sp. isolated from antarctic waters
	HE 800	Structurally analogous to hyaluronic acid	<i>Vibrio diabolicus</i>
PUFAs	DNA, EPA, and Omega-3 fatty acids	Soft tissue repair, skin nourishment and stimulation of collagen production	Marine fungi (<i>i.e.</i> , <i>Trichoderma</i> sp., <i>Rhodotorula mucilaginosa</i> AMCQ8A), bacteria (<i>i.e.</i> , <i>Moritella dasanensis</i> , <i>Vibrio</i> sp., <i>Pseudomonas</i> sp., <i>Shewanella</i> sp. and <i>Colwellia</i> sp.) and thraustochytrids (<i>in particular</i> <i>Schizochytrium</i> , <i>Aurantiocytrium</i> and <i>Ulkenia</i>)

Barone et al. (2017). Marine Microbial-Derived Molecules and Their Potential Use in Cosmeceutical and Cosmetic Products.

The table introduces types of marine-derived compounds used in the production of antiaging cosmetics along with the relevant bioactive compounds, their actions, and the source microorganisms.

The anti-ageing market in the United States is expected to reach a growth rate of 5.1% from 2021 to 2028, which implies an excellent prospect and great interest from scientists and consumers in anti-ageing research [11]. The fast discovery rate and higher growth rate of the market hint at a bright future in the field of antiaging cosmetics containing marine-derived compounds.

Likewise, considerable attention has been paid to the area of antibiotics containing deep-sea microorganism-derived natural compounds. A number of researchers have excavated a great chance of the discovery of a new source for the development of drugs against cancer or infectious diseases [12]. For industrial purposes, marine microorganisms have perfect properties related to the recent industrial microorganisms used for the production of antibiotics, such as availability in pure culture, genetic stability, larger-scaled culture, stability over long periods of time, rapid growth rates, the ability to grow in inexpensive liquid media, and ease of separation between media and biomass.

Thus, a number of scientists expect to see a new pathway along with a further understanding of antibiotics derived from marine microbes. Scientists look for more desirable molecular structures, more simplified production patterns, and enhanced product yields in the future. For the completion of the aim, more considerable effort must be made before the chance of the marine microorganism is fully noticed [13].

CONCLUSIONS

Marine biotechnology has shown its excellent potential as an emerging source of future resources and for further development of world sciences. The most-known sectors of marine biotechnology include enzymes, antiaging cosmetics, and antibiotic research.

Most marine-derived enzymes are accustomed to thriving in a harsh environment at deep sea level and various environments that are rarely found in land environments. Those properties of marine-derived enzymes are useful in many industrial fields, such as heat-sensitive processes, including gelling, and, in addition to this, many food industries have shown high demand for marine-derived organisms which are used as stabilisers and thickeners.

Additionally, considerable attention has been shown from the antiaging cosmetic industry. The vast properties of algae, including biodiversity, easy cultivation environment, and effective growth modulation, have resulted in the remarkable growth of antiaging cosmetic markets.

Likewise, antibiotics containing marine-derived organisms or microbes have attracted critical attention from the field. This is because of the various chemical classes found only in marine organisms and microbes. The most recent concern of scientists is "antibiotic resistance," which is expected to be treated soon with more discoveries of marine organisms or microbes.

Research into marine biotechnology is now being boosted by many scientists and governments. Many countries, like Japan, Canada, Finland, Russia, and Spain, have increased their support in the particular sector and successfully completed planning for more discoveries.

Besides, the possibility of the technology is seen through the excessive growth of interest in the field. For example, in the case of anti-ageing cosmetics, aforementioned, the United States anti-ageing market is expected to experience a growth rate of 5.1% by 2028. As the number of significant discoveries of new antibiotic chemicals has increased, more growth in the market is expected by analysts.

Although the number of researchers hints at a bright future for marine biotechnology, greater efforts by scientists should be made to further understanding and the development of marine biotechnology.

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